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Unpublished working document

DUPLICATE ALSO

An investigation of a surprising downward trend in estimated hydrologically effective rainfall on grassland at Kew.

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1. Estimates of hydrologically effective rainfall (h.e.r.) on grassland at Kew 1871-1976.

Monthly estimates were obtained using (a) daily rainfall data, (b) monthly estimates of (Penman) potential evaporation and (c) a Penman root constant of 3 inches (76.2mm).

2. Analysis of h.e.r. estimates and rainfall totals.

10-year running means of Water Year (Oct-Sep) total and hydrologically effective rainfall (for grassland) at Kew are shown in Fig. 1. A significant difference between the two graphs occurs after the 10-year mean commencing 1940, h.e.r. trending downwards without a corresponding downward trend in total rainfall. A better comparison is made by ignoring the summer half-year (April to September) when there is normally little or no effective rainfall. 10-year running means of winter half-year h.e.r. and total rainfall are shown in Fig.2. It can be seen that h.e.r. trends downwards more steeply than total rainfall from the 10-year mean commencing 1940 onwards.

3. Analysis of (Penman) potential and tank evaporation.

10-year running means of the (Penman) potential evaporation (p.e.) estimates for Kew used in calculating the h.e.r. values are given in Fig.3. (top graph). It can be seen that the graph trends upwards from the mean commencing 1945. 10-year running means of evaporation from the British Standard (BS) tank at Camden Square, (London) are shown from the mean commencing in 1885 to that commencing in 1933; there is generally good agreement with the Penman p.e. at Kew. 10-year running means of evaporation from a B.S. tank at Otterbourne (near Winchester) are shown from the mean commencing in 1934 to that commencing in 1958. Winchester is fairly remote from Kew and the lack of close similarity between the Otterbourne tank data and Kew (Penman) p.e. values is not surprising. 10-year running means of (Penman) p.e. for

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Heathrow and Shoeburyness and of B.S. tank evaporation at Kew are also shown. The Heathrow and Kew trends agree for means commencing 1954 to 1957. The Kew Penman and B.S. tank trends agree for means commencing 1957 to 1962. Differences between the trends are difficult to explain but, as Fig.4. shows, the pattern of annual totals of Penman p.e. at Kew from 1941 to 1970 is very well supported by those for Rothamsted, Heathrow and Shoeburyness.

4. Checks on input climatological data used in computing p.e. at Kew.

These data are monthly averages of air temperature, vapour pressure, daily duration of bright sunshine and wind speed (at or adjusted to 2m above ground). The data used were re-checked from 1945 to 1965 against source documents and found to be correct.

Possible sources of error arising from changes in methods of obtaining averages of data (imposed by changes in source documents and their formats) were also examined. Run of wind measurements at 2m began at Kew in 1957. Before this year, estimates of 2m wind (monthly averages) were obtained by multiplying the averages of speeds measured at 23m by 0.54. This factor was found from a direct comparison of speeds at 2 and 23m over the period 1957-70. If adjusted 23m average speeds had been used from 1957 onwards (in lieu of averages of measured 2m winds) the rising trend in p.e. would not have been altered.

Monthly averages of vapour pressure were published in Observatories Year Books up to 1956. From 1957 onwards averages were obtained from fixed hour data published in the Monthly Weather Report. Mean values of vapour pressure were obtained from computer archive tapes and compared with the data obtained from the MWRs. The two sets of data are very close indeed and the use of either in lieu of the other would not affect the rising trend in p.e.

It so happens that a second independent series of estimates of monthly p.e. at Kew is available for comparison. In this series, also, the rising trend is apparent.

5. Further analysis of Penman p.e.

The monthly p.e. totals for Kew from 1945 to 1965 are plotted in Fig.5.

10-year running means are shown, for each month in Figs 6a and 6b.

An upward trend is shown in:

Jan Feb Mar May Jun Jul Sep Oct Nov Dec

A downward trend is shown in:

Apr.

There is no firm trend in August p.e.

10-year running means of average daily duration of bright sunshine are plotted in Figs 7a, 7b and 7c.

An upward trend is shown in:

Jan - Mar May Jun - - Oct - Dec

A downward trend is shown in:

Apr Jul Aug

There is no firm trend in Feb, Sep and Nov p.e.

Wales-Smith has demonstrated the well-known correlation between average air temperature and Penman p.e. 10-year running means of average air temperature are plotted in Fig.8.

Rising trends in temperature in Feb, Mar, Jun, Sep, Oct are in accord with rising trends in p.e.

6. Comparison of Kew sunshine data with those from other places.

As a final check monthly averages of daily duration of bright sunshine at Kew for Jan, April, July and October are compared with averages at Edgbaston (Birmingham) and Mount Batten (Plymouth) in Fig.9. It can be seen that the year-to-year patterns for each of the four months are similar at Kew and Edgbaston and that there are marked similarities between the patterns at Kew and Mount Batten.

7. Conclusions.

It is concluded that the data used in computing Penman p.e. at Kew from 1945 to 1965 are correct and representative and that the downward trend in estimated

hydrologically effective precipitation on grassland at Kew is a genuine feature. It is noted, however, that this downward trend may not have occurred over the whole of the same period in other parts of southern England.

December 1976.

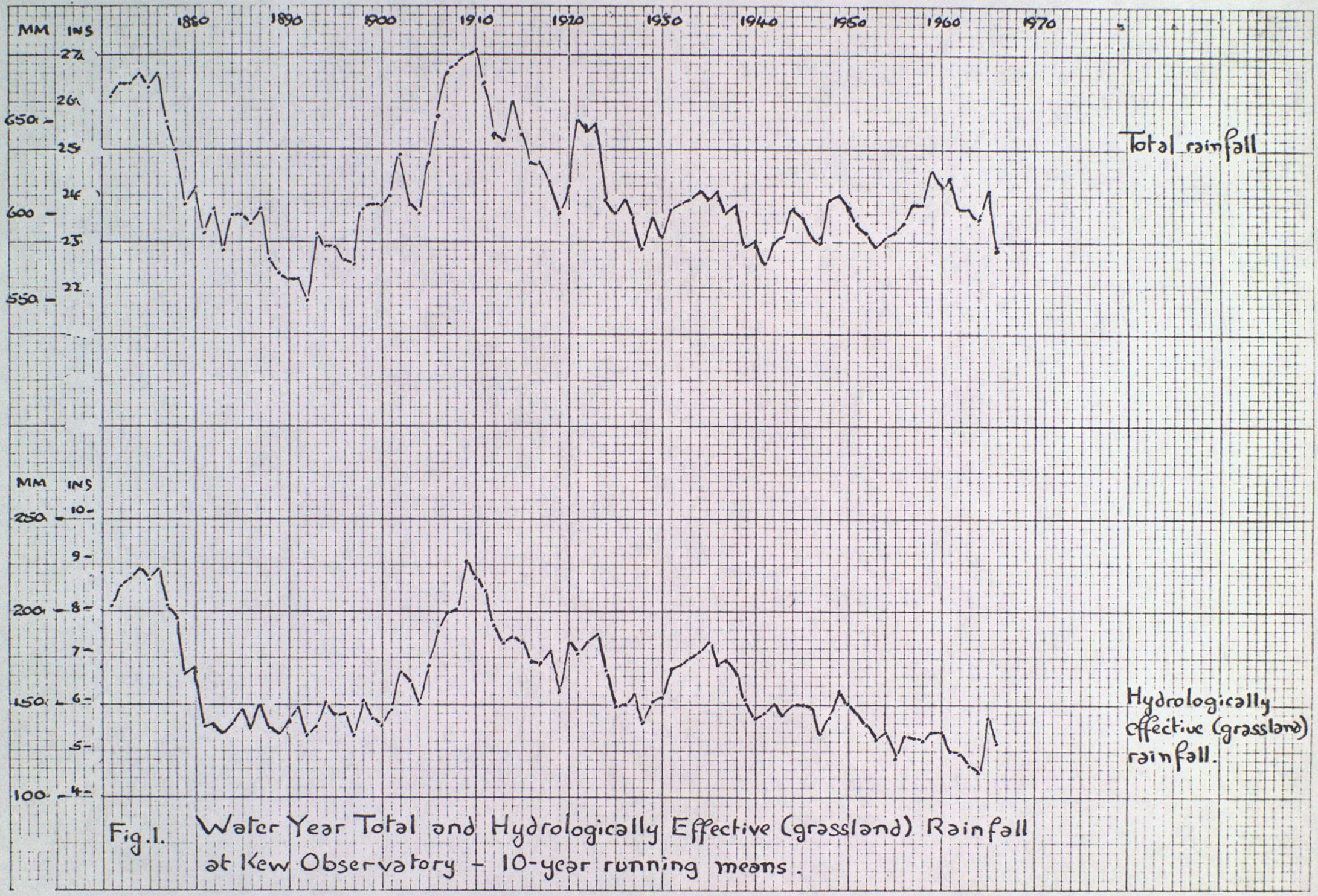


Fig.1. Water Year Total and Hydrologically Effective (grassland) Rainfall at Kew Observatory – 10-year running means.

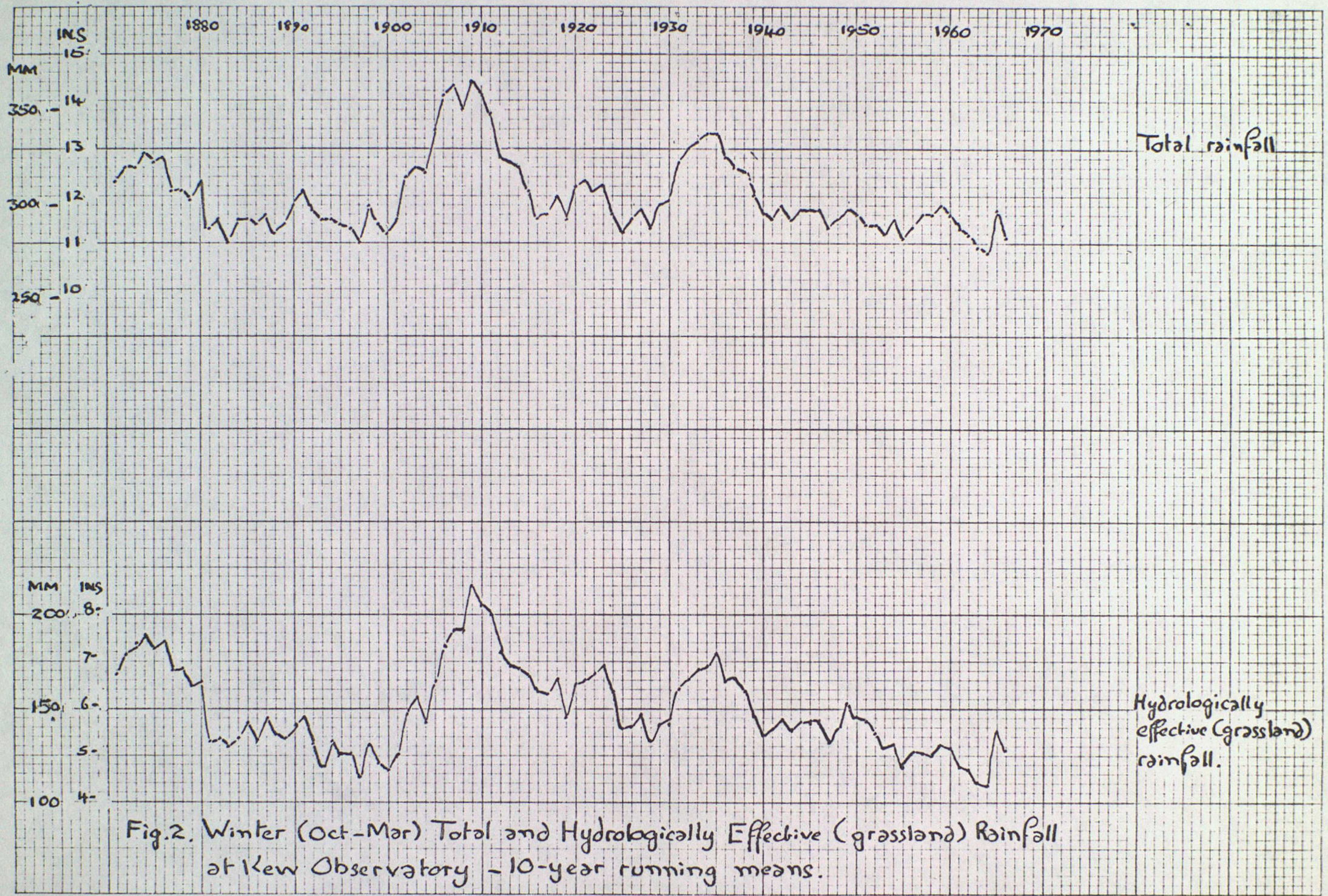


Fig.2. Winter (Oct-Mar) Total and Hydrologically Effective (grassland) Rainfall at Kew Observatory - 10-year running means.

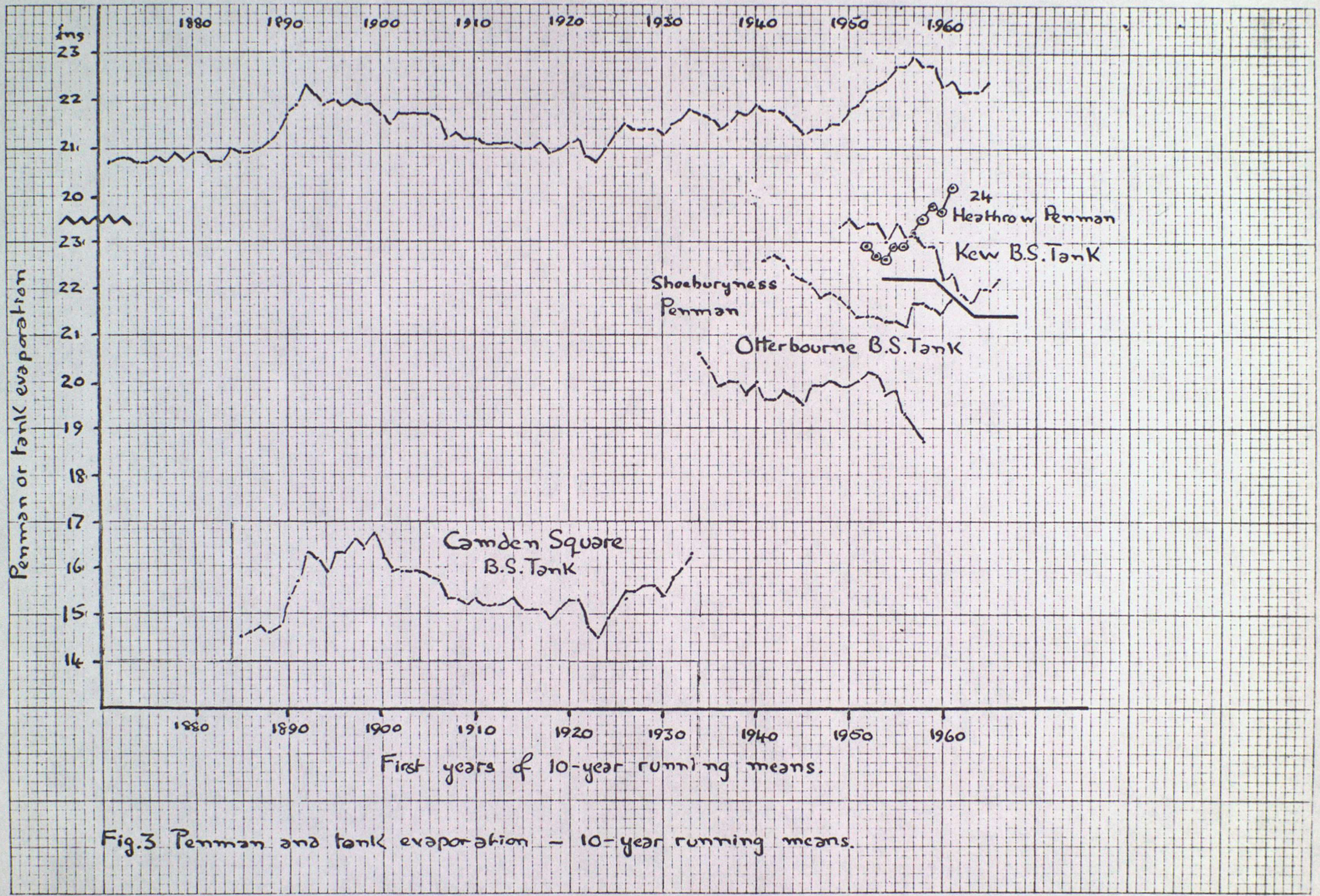


Fig.3 Penman and tank evaporation – 10-year running means.

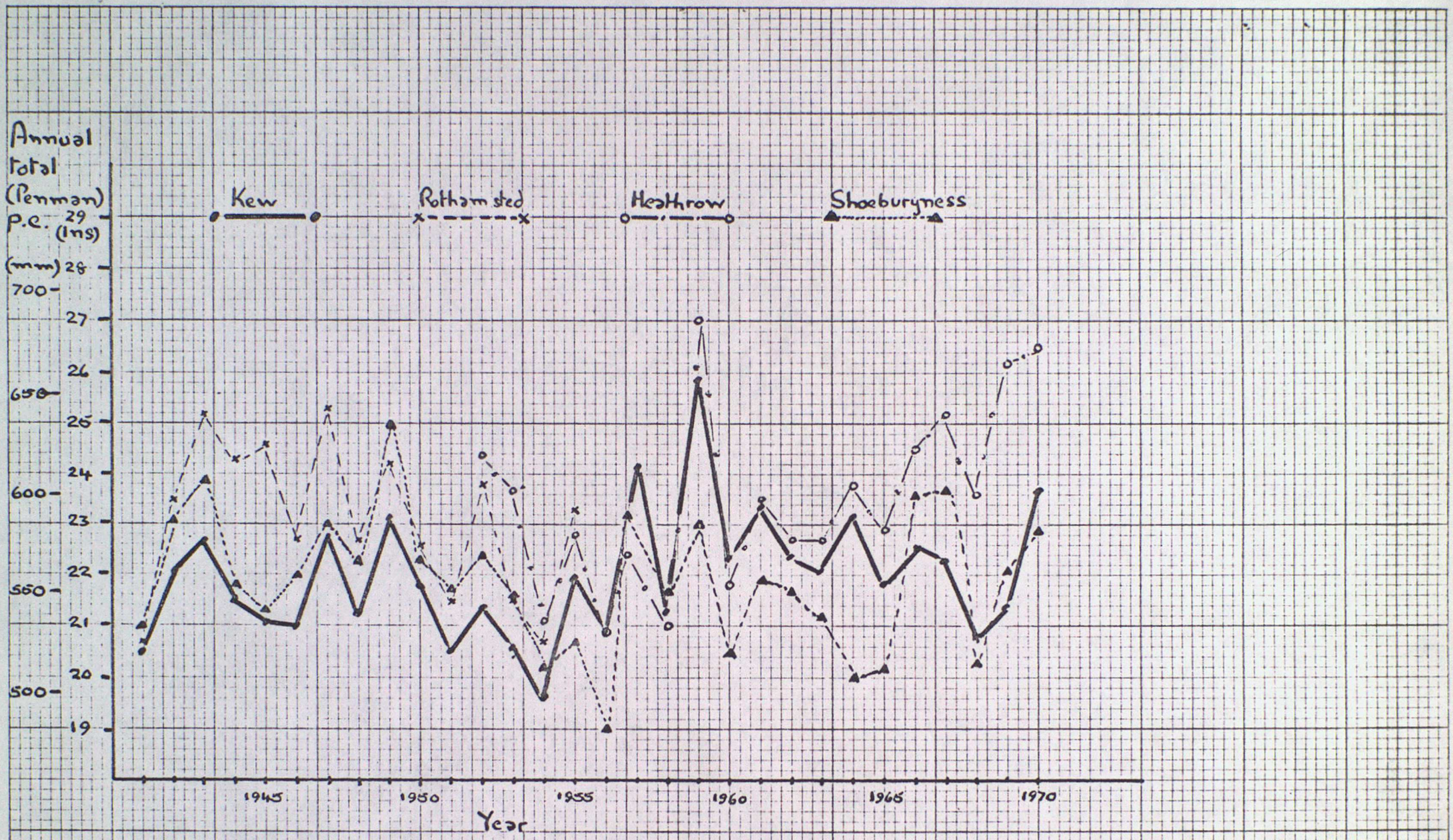


Fig. 4. Annual totals of Penman potential evaporation.

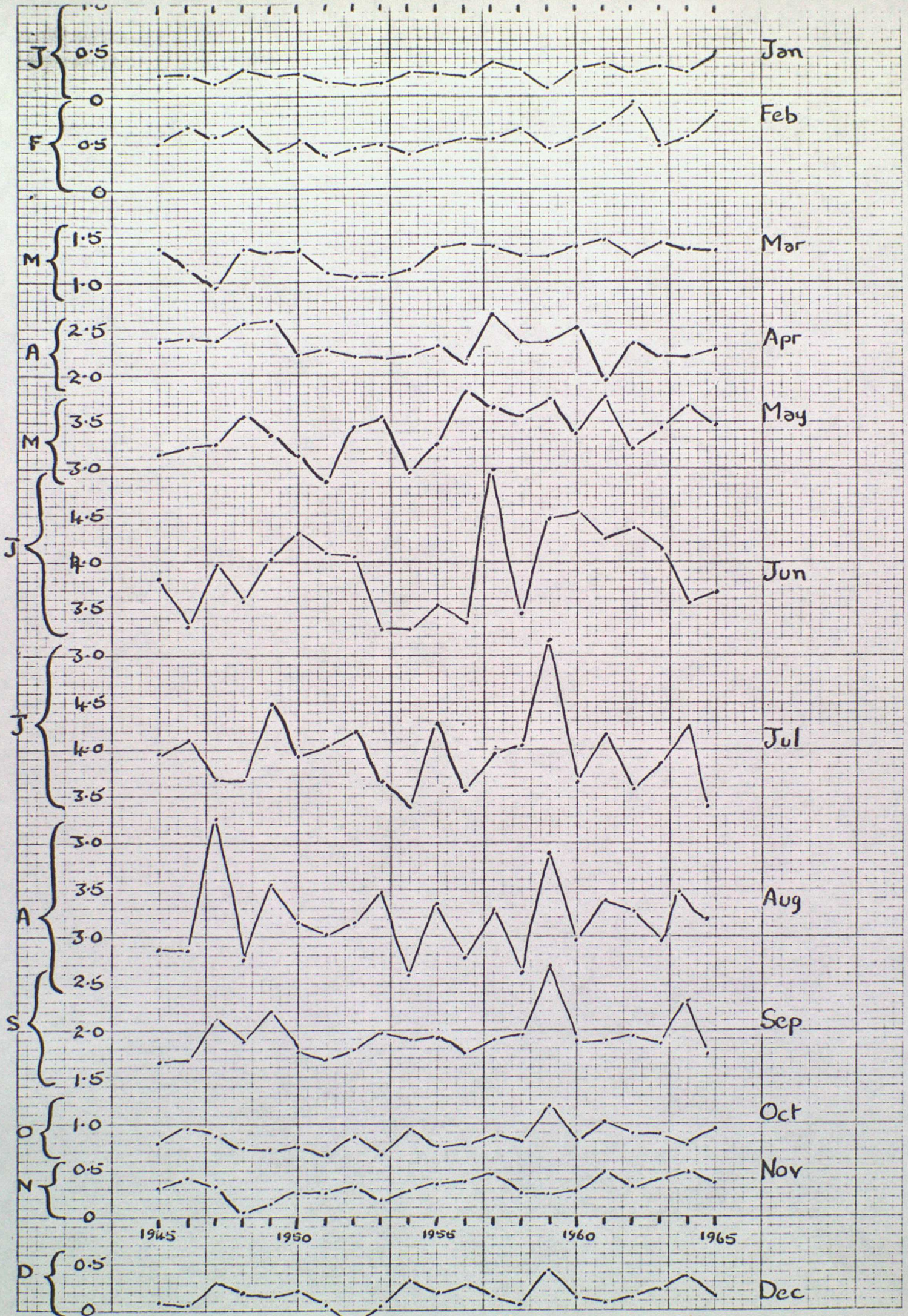


Fig. 5 Penman potential evaporation (albedo 0·25) at Kew

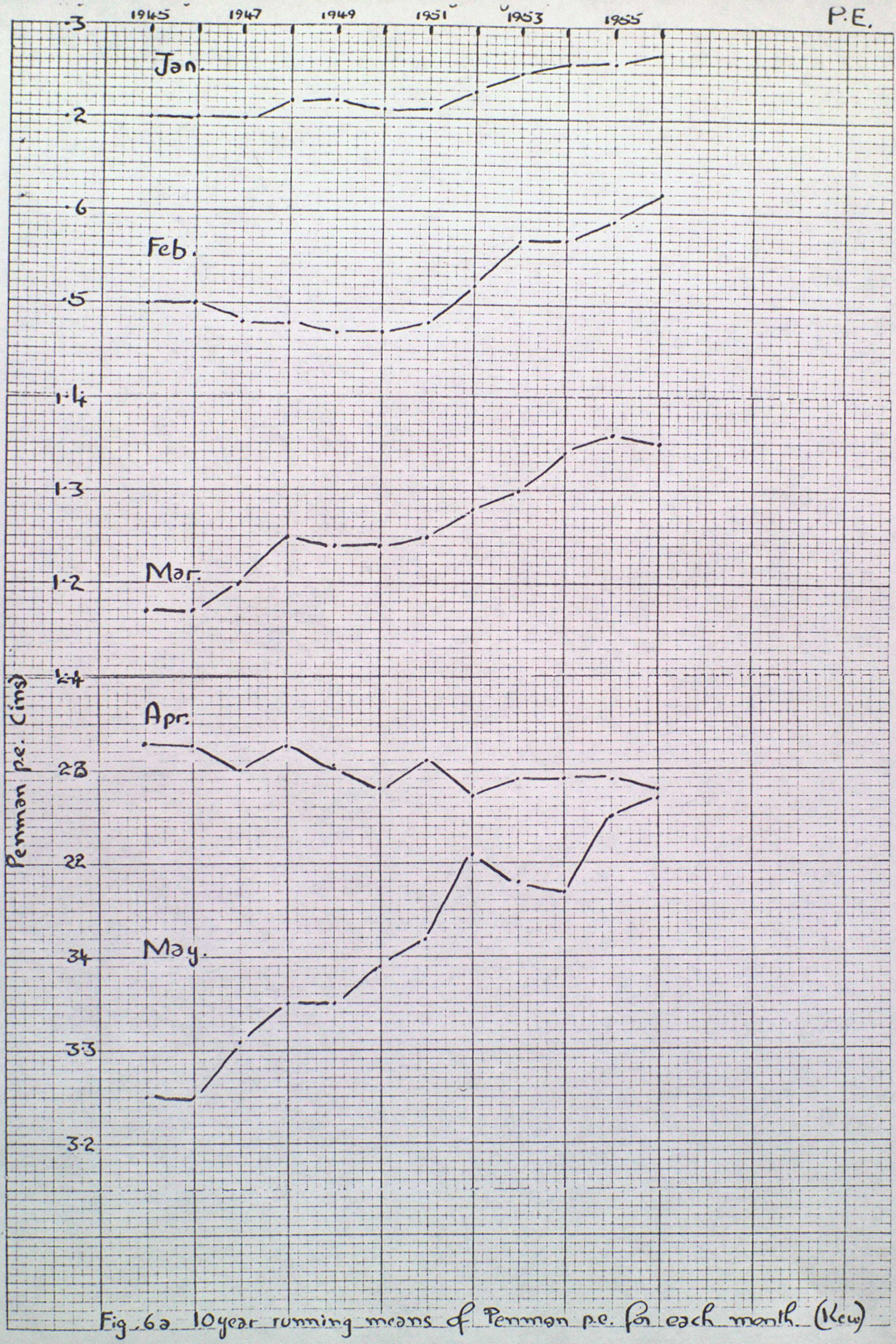
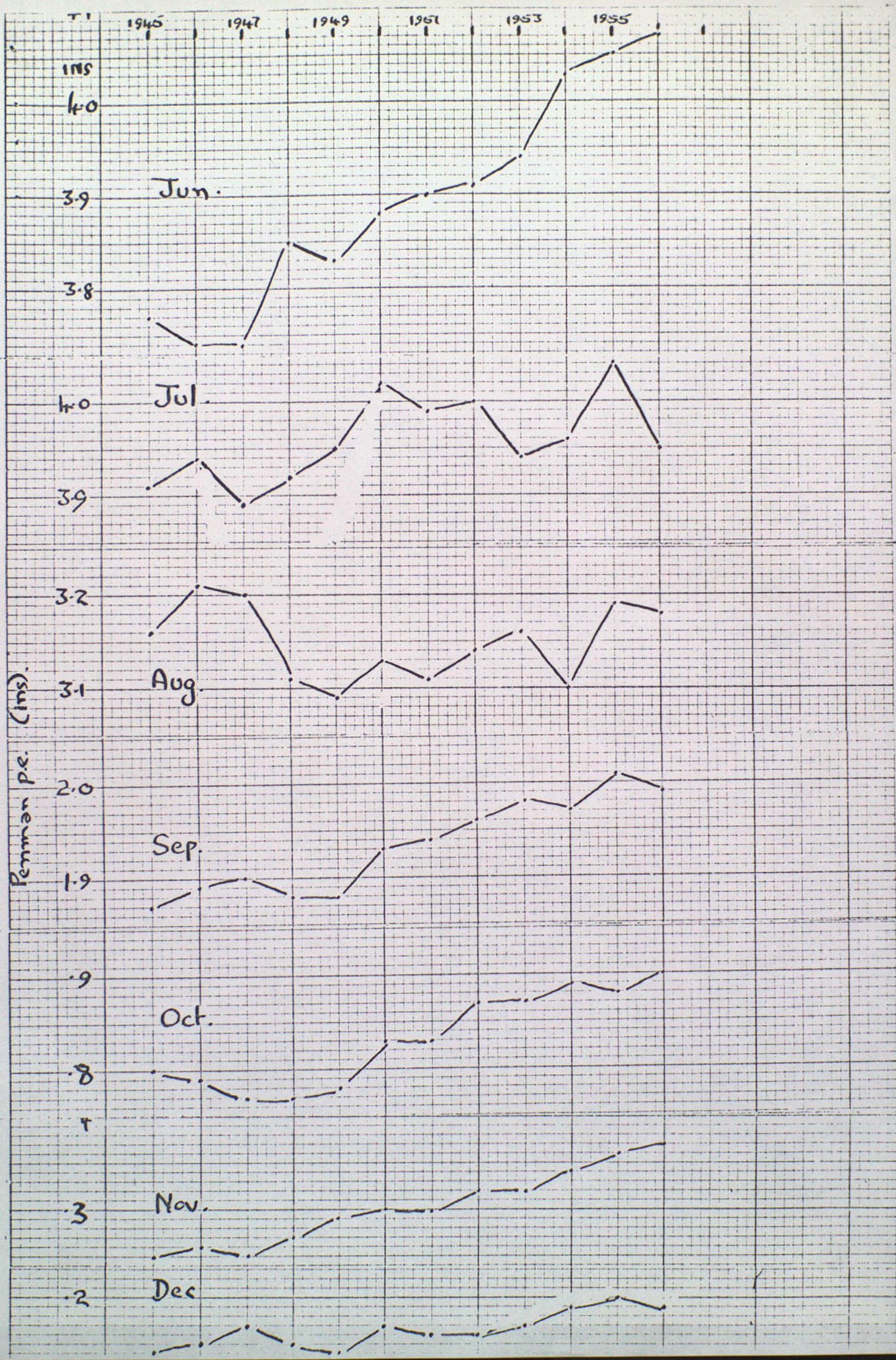


Fig. 6a 10 year running means of Penman p.e. for each month. (Kew)


1945
1947
1949
1951
1953
1955
4·0
3·9
3·8
Jun.
4·0
3·9
Jul.
3·2
3·1
Aug.
2·0
1·9
Sep.
·9
·8
Oct.
·3
·2
Nov.
Dec
Pennen pr. (ins).

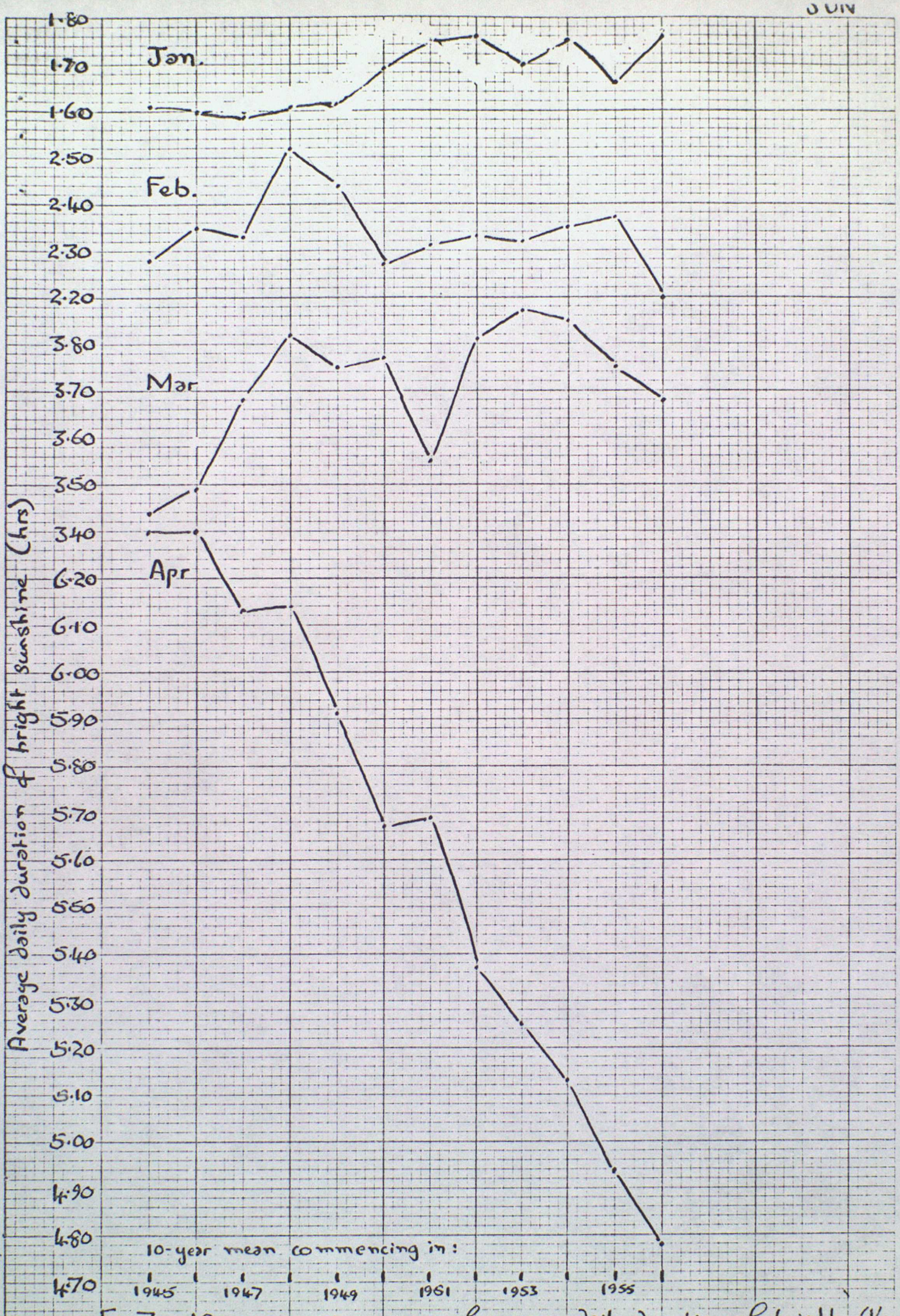


Fig 7a 10-year running means of average daily duration of bright (Kew) sunshine.

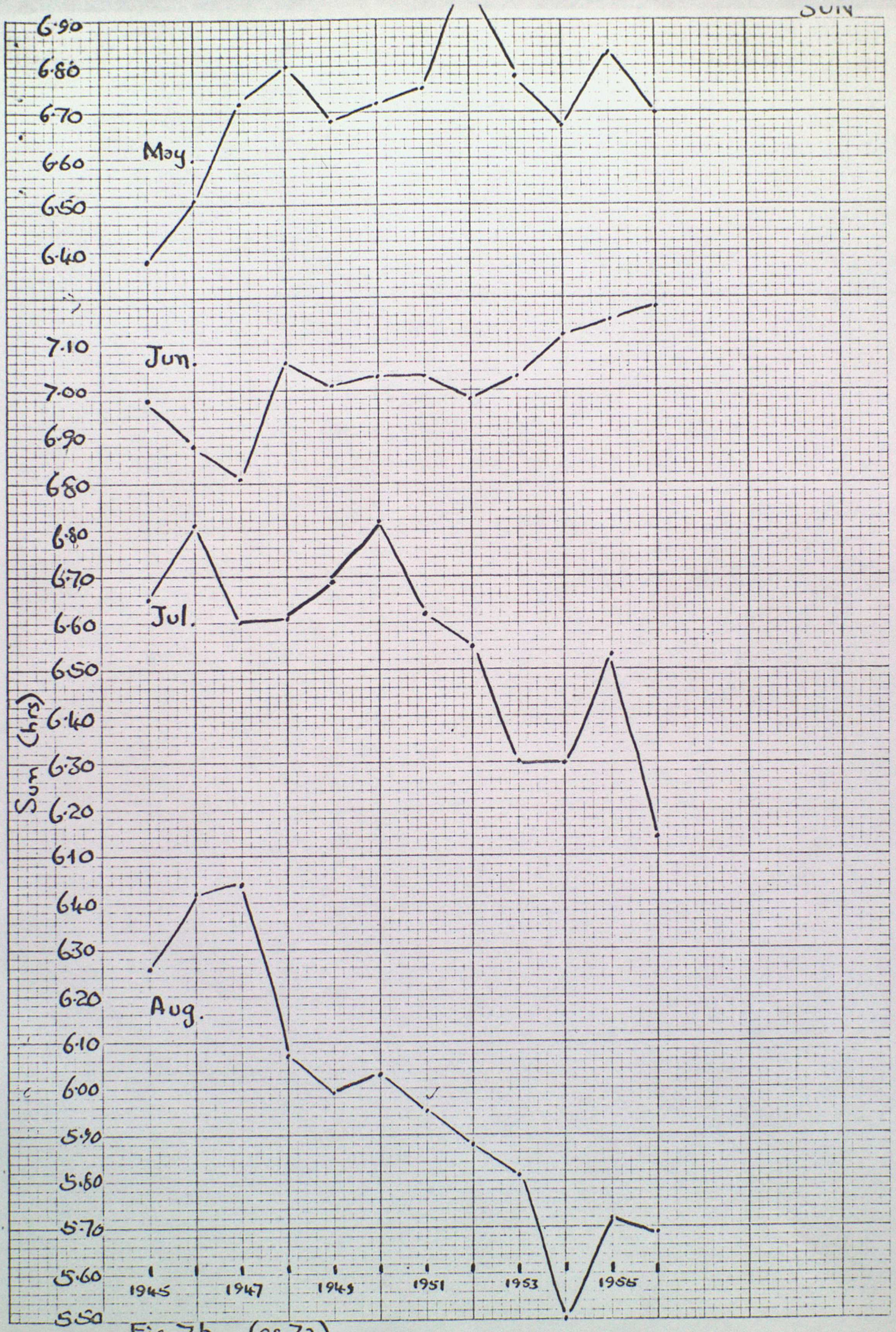

SUN
6·90
6·80
6·70
6·60
6·50
6·40
May.
7·10
7·00
6·90
6·80
Jun.
6·80
6·70
6·60
6·50
6·40
6·30
6·20
Jul.
Sun (hrs)
6·10
6·40
6·30
6·20
6·10
6·00
5·90
5·80
5·70
5·60
5·50
Aug.
1945
1947
1949
1951
1953
1955

Fig 7b (as 7a)

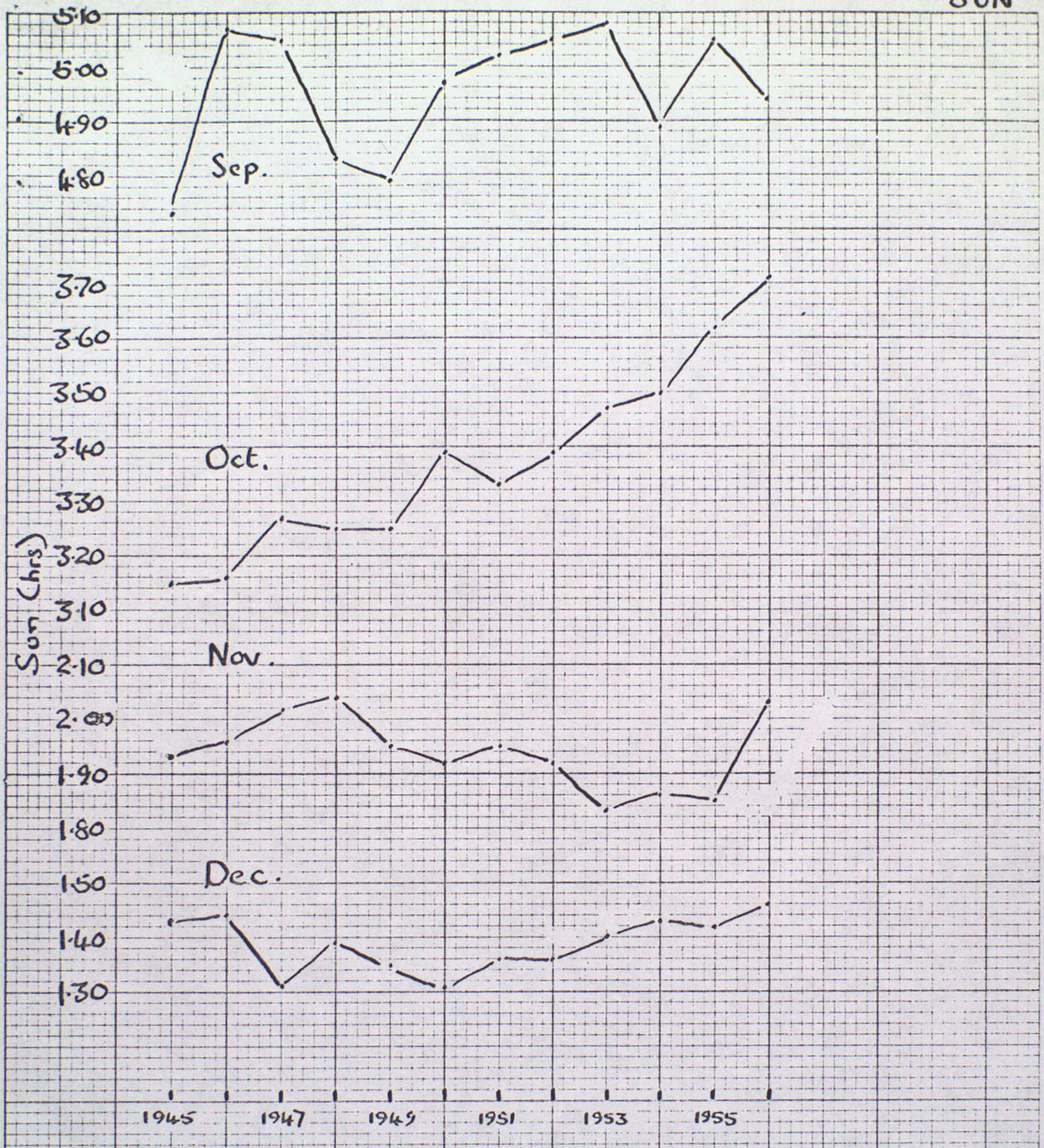

5·10
5·00
4·90
4·80
Sep.
3·70
3·60
3·50
3·40
Oct.
3·30
3·20
3·10
Sun (hrs)
2·10
Nov.
2·00
1·90
1·80
1·50
Dec.
1·40
1·30
1945
1947
1949
1951
1953
1955

Fig 7c (as 7a)

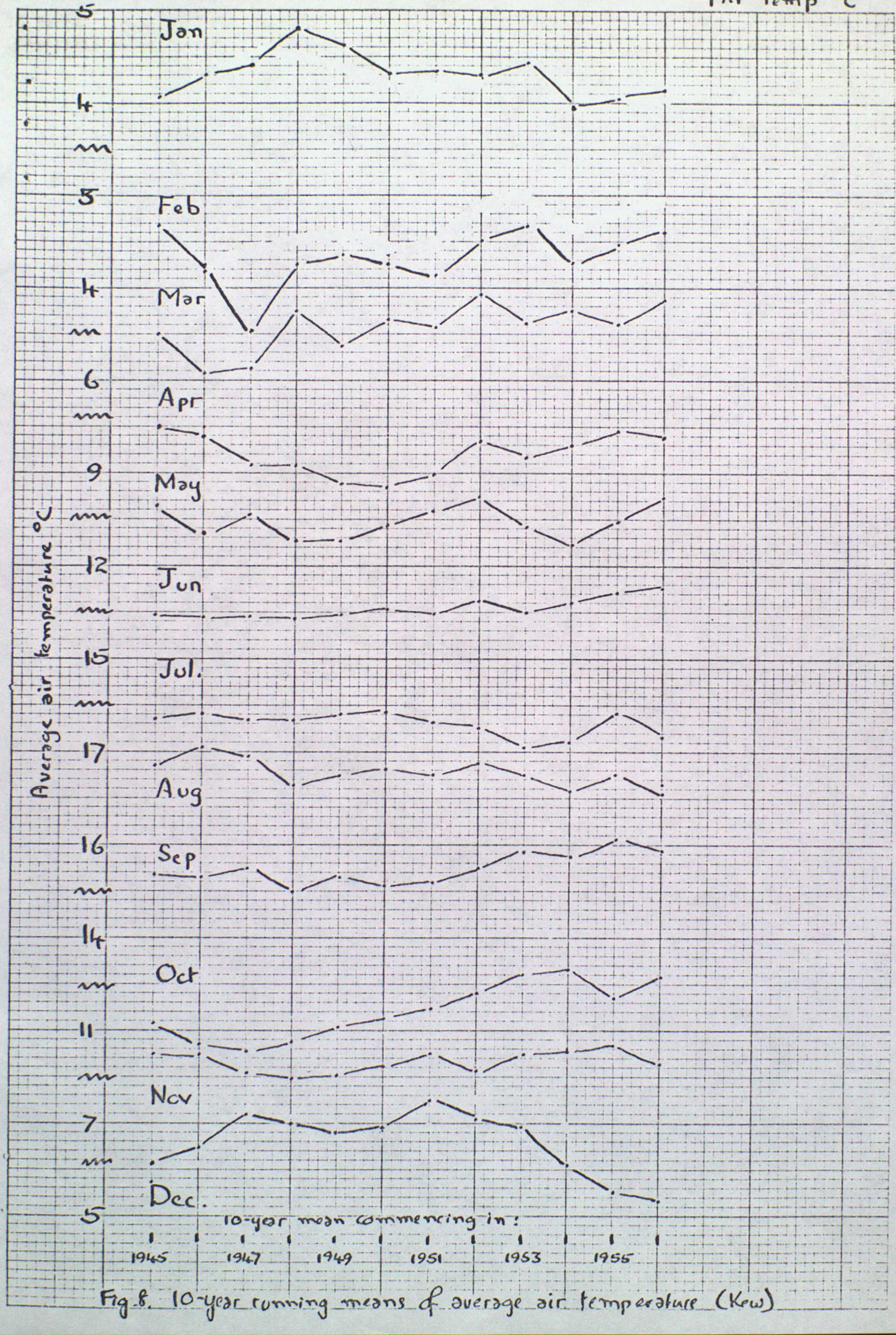


Fig 8. 10-year running means of average air temperature (Kew)

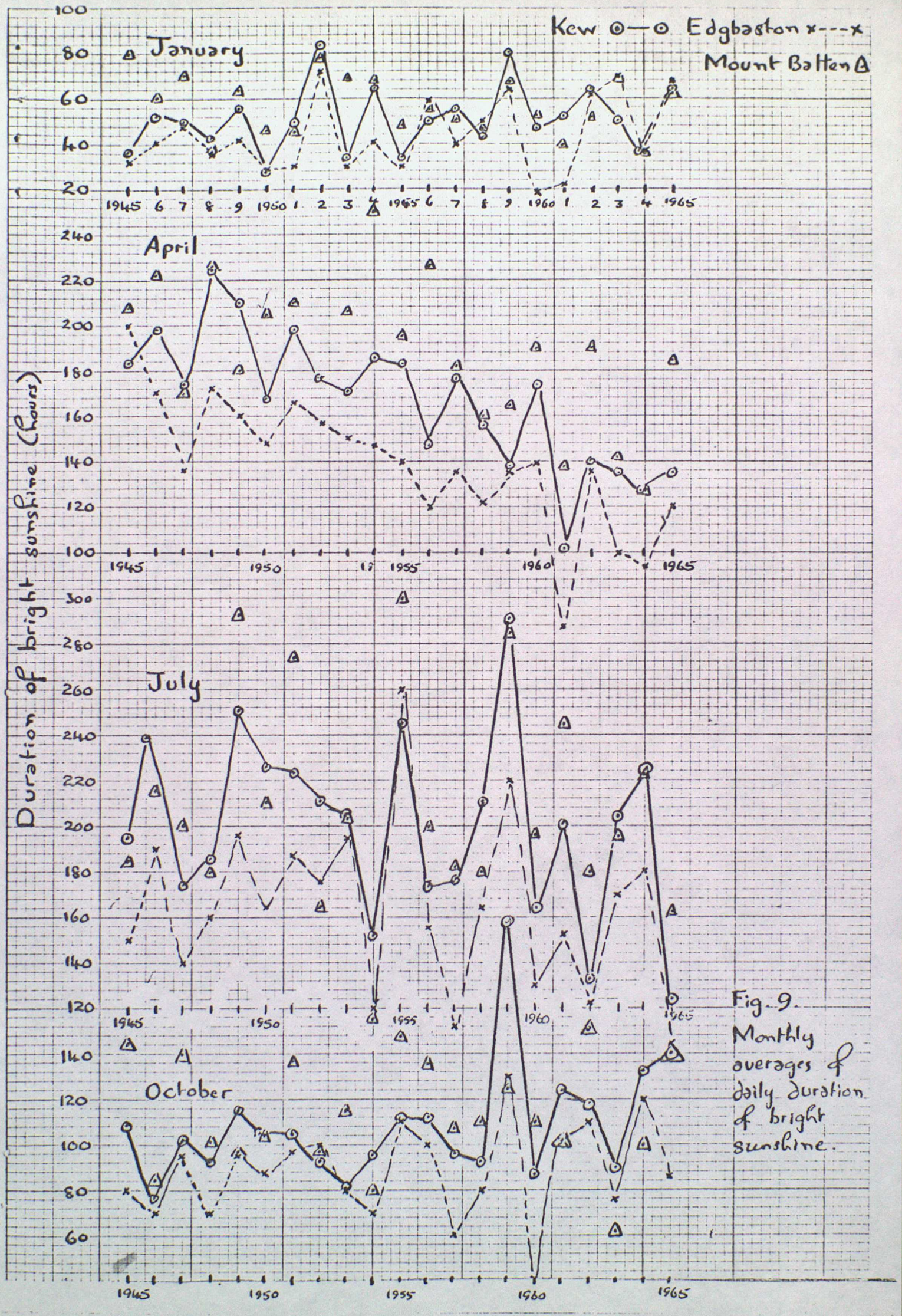


Fig. 9. Monthly averages of daily duration of bright sunshine.